ment. One real grievance, at any rate, is partly met. No guarantee is, however, offered that existing facilities generally given to women will be continued. They are now admitted to laboratories and lectures only by the courtesy of professors and other teachers. Cambridge is at present suffering from severe pressure on its accommodation. Under Report B women might well be crowded out from laboratories to make room for members of the University—this is fully recognised by the supporters of Report B; that is to say, the report amounts to a desire to assist in the teaching of women so long as the number of men students leaves room for them and no longer. It is no wonder that the councils of the women's colleges at Cambridge have emphatically repudiated such a scheme, and have declared that if Report B is adopted at Cambridge they would take no steps to promote the incorporation of Girton and Newnham Colleges as a separate University. It is no longer possible, in our view, for a university, in sorting out its excess applicants for entry, to take sex as the first and supreme test: intellect and the needs of the nation are both safer tests in the interest of the university and of learning.

One more point in which Report B singularly fails to make good the claims of its supporters may be briefly mentioned. As regards the admission of women to the men's colleges, and through the colleges to the University, it leaves the door wide open as it has stood since the Sex Disability (Removal) Act. It is Report A, and not Report B, which takes safeguards against what is admitted on all sides to be undesirable. It is Report A which, with this precaution, gives women the fullest equality of opportunity with men inside the University.

Lunar Tables.

Tables of the Motion of the Moon. By Prof. Ernest W. Brown, with the assistance of Henry B. Hedrick. Sections i. and ii., pp. xiii + 140 + 39; section iii., pp. 223; sections iv., v., vi., pp. 99 + 56 + 102. (New Haven: Yale University Press; London: Humphrey Milford; Oxford University Press, 1919.) Price, 3 vols., 4 guineas net.

THE appearance of Prof. E. W. Brown's lunar tables marks the accomplishment of an arduous task of the highest importance to astronomy. In the two centuries which have elapsed since the time of Newton more than a score of tables have been published. The majority of them naturally belong to the eighteenth century, and no longer possess any practical interest apart from the theories on which they were based. If they did not always mark any very distinct advance in accuracy beyond their predecessors, they generally aimed at including a greater number of inequalities more precisely determined, and systematic observation of the moon was all the time accumulating the material which could be used for comparison with theory and the better determination of the fundamental constants. Newton himself discussed eight lunar inequalities. Euler in his memoir of 1772 included twenty-one inequalities each in the longitude and the radius vector and sixteen in the latitude. This was only a beginning. As time went on and the standard of achievement grew more exacting it is not surprising to find that the number of men who possessed both the ability and the patient energy to elaborate complete and independent theories of the moon's motion and to reduce them to the form of practical tables became notably smaller. Thus when Burckhardt's tables of 1812 had once been adopted in such annual publications as the Nautical Almanac, overcoming the rival claims first of Bürg and later of Damoiseau, they continued in use for the best part of half a century, although their deficiencies ultimately amounted almost to a scandal, and their form rendered it particularly difficult to reconstruct the underlying theory and to apply the needful corrections. A serious error in the parallax according to these tables was found and corrected by Adams.

The Greenwich lunar reductions undertaken by Airy, by which the results of eighty years' observations were made available, proved the need for greatly improved tables, and provided the most valuable material on this side for making an advance. By that time it was known that Hansen was engaged in lunar researches having for their ultimate object the preparation of entirely new tables, and their appearance was eagerly awaited. But for a time difficulties threatened to intervene. Born in Schleswig in 1795, Hansen is an outstanding example of that singularly rare class, the self-taught mathematician. Owing nothing to academic education, he succeeded Encke in 1825 in the direction of the observatory at Gotha, and thereafter until the end of his long life refused all offers of preferment, though observatory and stipend were alike of the most modest. In these circumstances he received help from the Danish Government, but when this was discontinued in 1848 owing to financial stringency and the steady progress of the work was in danger, the British Admiralty came to the rescue on the representation of Airy in 1850, and not only provided the comparatively small sum needed to complete the work, but also undertook the expense of printing the tables, which accordingly were ready for distribution in 1857. As his earliest researches on the subject were published in 1829, it may be taken that the work filled the main part of Hansen's life for a period of about thirty years.

No excuse is needed for recalling these circumstances at the moment, sixty years later, when Hansen's tables are on the point of being finally superseded. They are not faultless, it is true, and for many years past certain corrections introduced by Newcomb have been adopted in the national ephemerides. But, on the whole, they have served the practical needs of two generations admirably. In Hansen's theory, on which the tables are based, the number of periodic terms had grown to about three hundred. Those which depend on the solar action were for the most part well determined, but those which arise from planetary action were neither complete nor accurate. It is but fair to remember, however, that in previous tables the latter class of terms had been ignored altogether. Considered purely as tables in the technical sense, Hansen's possess acknowledged merits. As a practical computer himself, he had the advantage of great experience and exceptional natural gifts. It is said that in a matter of four-figure logarithms he rarely had need to refer to the tables.

But during the later stages of his researches Hansen was not the only worker on the large scale in the field of lunar theory. Some ten years earlier Delaunay had begun the construction of a theory in purely algebraic form by an original method of integration, and by 1867 that part which depends on the direct action of the sun had been completed and published. His intention had been to add those complementary parts which still remained necessary and to proceed to the reduction of the whole to a numerical and tabular form. This was not to be. Historical events supervened and delayed the progress of the work. Then in 1872 he lost his life by drowning, and his life's work, which had always been pursued without assistance, came to an untimely end. Yet his projects were destined to be accomplished by other hands. The planetary inequalities were calculated by Radau in an admirable memoir, and under his direction the reduction of Delaunay's theory to tabular form was completed before the death of Radau in 1911. From 1915 the lunar ephemeris in the "Connaissance des Temps" is based on these tables. Prof. Brown remarks justly that the value of the purely algebraic development is not seen at its best in the numerical form, owing to the slow convergence of certain classes of coefficients. He also criticises the form of the tables, but this is a matter which will chiefly concern the French computer, and need not affect our appreciation of an independent lunar ephemeris. The value of Delaunay's method is not confined to his own application of it to the lunar theory. But even this can be no ordinary work, which, executed within a few years of Hansen's, assumes a new vitality after lying dormant for half a century.

The new tables of Prof. Brown will be used for the first time in the Almanacs of 1923, and a confident hope may be expressed that they will continue in use for a very long time to come. They are the final outcome of thirty years' work, and, long as this time is, Prof. Brown is to be congratulated equally on the rapidity and on the thoroughness of his labours. For the number of terms now included falls little short of 1500, and, so far as can be now seen, the expression of the effects of purely gravitational action cannot profitably be pushed further. All this work, which is completely new from the beginning, was not contemplated as an integral plan from the start, but grew by successive stages, as Prof. Brown tells us, out of a suggestion by Sir G. H. Darwin to make a study of Hill's papers. The preparation of the theory, which was published in the Memoirs of the Royal Astronomical Society, was finished in 1908, and the liberality of Yale University in undertaking the whole cost of the tables made it possible to proceed with plans for the final stage without delay and without anxiety. Thus the author has been spared some of the cares which fell to the lot of Hansen. None the less, the British Admiralty has once again played a small part in the matter, though in a different way. With proofs and MS. continually crossing the Atlantic during the war, it is recorded that only one set of returning proofs was lost.

It is unnecessary to recall the details of the author's theory. Hill, to whom its foundations are very largely due, was, like Hansen, a practised computer. Though his researches in this field have incidentally enriched celestial mechanics, and even mathematics in general, with new and fertile conceptions, his motive was essentially a practical one. It was to find a path which would lead to the highest possible accuracy in the final results with the greatest economy of labour. The soundness of his ideas can be properly tested and appreciated at no stage short of the fulfilment which Prof. Brown has given to them in this great work. There can be no doubt not only that Prof. Brown has accomplished a worthy and most valuable task, but that he has also with equal judgment employed in the course of it the best available methods.

Sections ii.–vi. contain tabular matter exclusively. The explanation of the tables is contained in the ten chapters of section i. This appears to be a model of clearness. Except in chronological questions and in special researches the ordinary astronomer rarely has occasion for single places of the moon outside the range of the hourly ephemeris provided in the Almanacs. The chief function of the tables therefore lies in the calculation of this ephemeris from year to year, and this fact has been kept in view in their arrangement. Advantage has been taken of Hansen's example to the extent deemed profitable, and a number of original devices have been introduced, including a new scheme of re-entrant arguments. By these means it is believed that the computation of an ephemeris will be at least as rapid as with Hansen's tables, in spite of the inclusion of about five times as many terms. An accumulation of errors in the sums of many tabular entries is unavoidable. From this source probable errors of 0·04″ in the longitude or latitude, and of 0·003″ in the parallax, are expected after these co-ordinates have been finally contracted to one decimal place less. Imperfections in the adopted constants and cumulative small defects of theory may raise these amounts to ±0·1″ and ±0·05″ respectively. Clear instructions are given for making such adjustments in the fundamental constants as may hereafter prove necessary. But there need be no illusion that the moon will actually follow the strict gravitational path laid down so carefully in these tables. As it is, the empirical term

$$+10{\cdot}71'' \sin \{140{\cdot}0^\circ (t_c - 18{\cdot}5) + 170{\cdot}7^\circ\},$$

with a period of 257 years, has been admitted in the longitude, with consequential changes in the arguments of some other terms. In magnitude this is comparable with the great Venus term, and the explanation of it is still to seek. Discrepancies will recur, and the advantage to be expected from the new tables is that they will no longer be entangled with the errors of a faulty ephemeris. If this hope is realised—and there is no reason to doubt that it will be—unstinted gratitude will be due to Prof. Brown and to those who have assisted him either by active collaboration or by financial aid.

The tables have been printed in England at the Cambridge University Press. The paper is of an unusually sumptuous and durable quality appropriate to a work of lasting value which will have to bear repeated handling for a long time. The type is admirably clear. Only one superficial point suggests adverse comment. The pagination is peculiar. In their present form the tables consist of six sections in three volumes. Each section, of length varying from 39 to 223 pages, is paged independently from 1 onwards. In whatever form the work is finally bound, this will surely prove an inconvenient plan for any purpose, such as the correction of errata. A continuous sequence would have been preferable. But perhaps there will be no errata (beyond one already noted), and in any case the blemish, if it be one, is trivial.

H. C. P.

Genesis, Evolution, and History.

The Evolution of the Earth and Its Inhabitants. By Joseph Barrell and Others. A Series of Lectures delivered before the Yale Chapter of the Sigma Xi during the Academic Year 1916–1917. Pp. xiv+208+iv plates. (New Haven: Yale University Press; London: Humphrey Milford; Oxford University Press, 1918.) Price 10*s*. 6*d*. net.

THIS book consists of five lectures by five experts, who deal with various aspects of evolution. The range extends from the nebula to modern civilisation, and the wonder grows that one word can cover it all. We feel as if the word "evolution" were in danger of becoming like a household knife—used in so many ways that it tends to become useless. The use of the same term for so many different kinds of becoming is apt to suggest that they are all describable by the same formulæ. To avoid this fallacy, might it not be well to find differentiated terms, such as *genesis* in the domain of things, *evolution* in the realm of organisms (keeping *development* for the becoming of the individual), and *history* for the kingdom of man?

The first lecture deals with the genesis of the earth and of the parent solar system, and, the establishment of the earth having been accounted for, its subsequent changes are traced until the time of its becoming a fit home for life. Prof. Barrell adopts the theory of the origin of the earth as a secondary spiral nebula heaved off from the central sun as the result of tidal forces produced by the close approach and passage of another star. He favours the hypothesis of earth-growth by the rapid infall of planetoids (not by Chamberlin's "slow accretion of planetesimals") and the hypothesis of an earth initially molten.

The second lecture, by Prof. Schuchert, discusses the changes of the earth's surface and climate during geologic time, which the author is inclined to put at about 800 million years. The constant shrinkage of the earth leads to an instability of surface that brings about periodic changes, not only in the areal space-relations of water and land, but also in the shapes and heights of the